

CropWatch

Real-time delivery of spatial-temporal information for farmers.

User Manual (document)

UNE COSC591/594 (Group A & C)

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Table of contents

| | |
|---|----------------|
| Project team and Client | 2 |
| Stakeholders | 2 |
| User Manual | 3 - 47 |
| CropWatch: Cloud Function to obtain farm-calculations data | 7 - 25 |
| CropWatch: Exporting farm data to the Database (BigQuery) | 26 - 29 |
| CropWatch: Visualizing Database information in DataStudio | 30 - 41 |
| Repository (Github link) | 41 |
| Notices | 42 |
| Licenses | 43 - 47 |

Project:

CropWatch: Real-time delivery of spatial-temporal information for farmers.

CropWatch is an application built to deliver interactive maps to farmers, showing details of their crops over time. The data for the maps are time-series data obtained from satellite and other spatio-temporal sources. The application gathers the data, filters out important information bands within the data, then exports the data into a cloud database which conducts transformations and calculations on that data to provide useful information to farmers via data visualization reports.

Project team and client

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UNE COSC594 students:

- Jason O. Aboh
- Steve Daniel
- Client: James Brinkhoff from Applied Agricultural Remote Sensing Centre (AARSC)

Stakeholders

- Project team: Zoe Dowsett, Qiaoling (Ling) Chen, Jason O. Aboh, and Steve Daniel
- Client: James Brinkhoff (AARSC)
- Project sponsor/Supervisor: Edmund Sadgrove (UNE)
- Suppliers: Google Cloud Platform, satellite and other spatio-temporal sources.

- End users: Farmers in Australia

CropWatch

Real-time delivery of spatial-temporal information for farmers

User Manual

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CropWatch

Real-time delivery of spatial-temporal information for farmers

User manual

By: Jason O. Aboh

Release 0.1

Before using this information, please be sure to read the general information contained under the “Notices” on page 42 and “Licenses” chapter on page 43 to page 47.

This edition applies to

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CropWatch: Cloud Function to obtain farm-calculations data

The python code to create the CropWatch data is hosted within a Google Cloud Platform function using a Python 3.9 runtime. The function is named ‘farm-calculator’ and consists of 4 files: “main.py”, “requirements.txt”, “farm_details.json”, and “sa-private-key.json; these files are required to run the cloud function successfully.

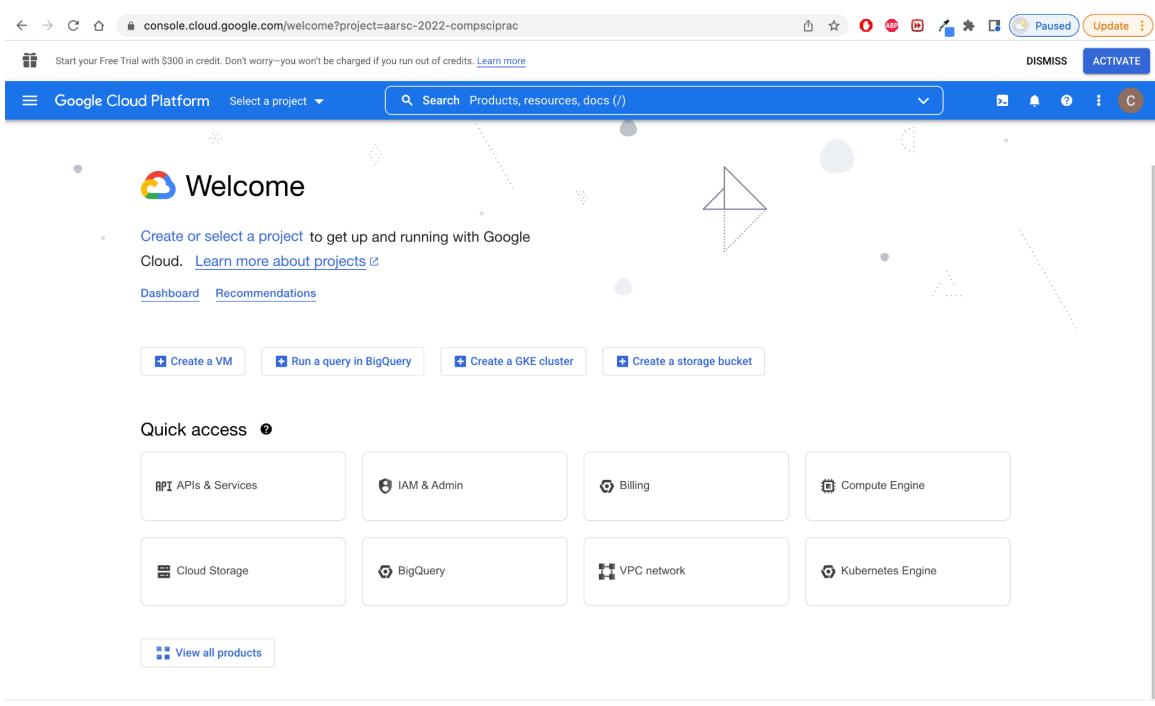
STEPS:

Getting to the project:

- After project set up and appropriate assignment of permissions and access to team members; Open up your browser and head to :

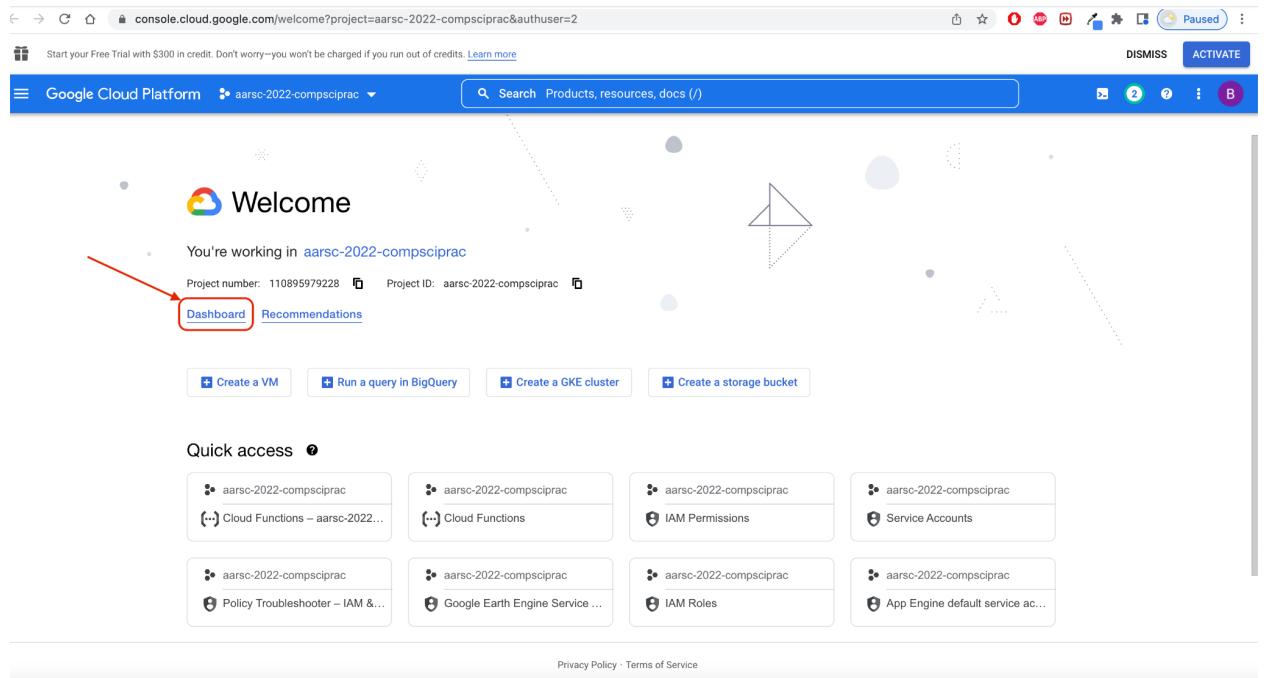
<https://console.cloud.google.com/welcome?project=aarsc-2022-compsciprac>

If you are not logged into an account with access permission, you might see the below screen that has a “select project” drop down at the left of the search bar”:



Tip: If you see something similar to the above page, please log into an account with access to the project.

- When logged into an account with access to the project, you will see the project name loaded within the different services; please navigate to the dashboard and click on the link:



- While on the dashboard, head over to the “Cloud Functions” service under the “Resources” section, and click on it:

Google Cloud Platform Dashboard (aarsc-2022-compscicprac)

Project info

- Project name: aarsc-2022-compscicprac
- Project number: 110895979228
- Project ID: aarsc-2022-compscicprac

Resources

- BigQuery
- SQL
- Compute Engine
- Storage
- Cloud Functions
- App Engine

RPI APIs

Requests (requests/sec)

Google Cloud Platform status

Billing

Monitoring

- Next; head over to the existing functions and select the “farm-calculator” function:

Google Cloud Platform Functions (aarsc-2022-compscicprac)

| Environment | Name | Region | Trigger | Runtime | Memory allocated | Executed function | Last deployed | Authentication | Actions |
|-------------|-----------------|----------------------|---------|------------|------------------|-------------------|--------------------------|----------------|---------|
| 1st gen | farm-calculator | australia-southeast1 | HTTP | Python 3.9 | 256 MB | main_function | May 30, 2022, 8:06:05 PM | | ⋮ |

- Once clicked and after the new page loads up, navigate to and click on the “Source” tab, it is two tabs to the right of the “Metrics” tab; On the left side of the screen, we can see 4 files, namely: “main.py”, “requirements.txt”, “farm_details.json” , and “sa-private-key.json”.

<img alt="Screenshot of the Google Cloud Platform Cloud Functions interface showing the 'farm-calculator' function details. The 'SOURCE' tab is selected, displaying the 'main.py' code. The code is highlighted in red from line 1 to 6, and in purple from line 9 to 31. The code is as follows: 1 import ee 2 from datetime import date, timedelta, datetime 3 import json 4 from google.cloud import storage 5 from google.oauth2 import service_account 6 import json 7 8 # Function to calculate NDVI and other vegetation indices for each image in a Sentinel-2 collection 9 # B2 = BLUE 10 # B3 = GREEN 11 # B4 = RED 12 # B5 = Visible and Near Infrared 13 # B8 = Near Infrared 14 # B8 = Near Infrared 15 # B11 = Short Wave Infrared 16 image = ee.ImageCollection('COPERNICUS/S2').select(['B2', 'B3', 'B4', 'B5', 'B8', 'B11']).filterBounds(geometry).select(['B2', 'B3', 'B4', 'B5', 'B8', 'B11']).divide(10000).copProperties().set('system:time_start', date.today().isoformat()) 17 image = image.addBands(image.normalizedDifference(['B2', 'B3']).rename('ndvi')) 18 image = image.addBands(image.normalizedDifference(['B4', 'B5']).rename('gndvi')) 19 image = image.addBands(image.normalizedDifference(['B5', 'B8']).rename('grvi')) 20 image = image.addBands(image.select(['B11']).divide(image.select('B5')).subtract(1).rename('cig')) 21 image = image.addBands(image.select(['B11']).divide(2.5 + ((image.select('B11') / (image.select('B11') + 7.5) - 1))) 22 . 23 . 24 . 25 . 26 . 27 . 28 . 29 . 30 . 31 . 32 . 33 . 34 . 35 . 36 . 37 . 38 . 39 . 40 . 41 . 42 . 43 . 44 . 45 . 46 . 47 . 48 . 49 . 50 . 51 . 52 . 53 . 54 . 55 . 56 . 57 . 58 . 59 . 60 . 61 . 62 . 63 . 64 . 65 . 66 . 67 . 68 . 69 . 70 . 71 . 72 . 73 . 74 . 75 . 76 . 77 . 78 . 79 . 80 . 81 . 82 . 83 . 84 . 85 . 86 . 87 . 88 . 89 . 90 . 91 . 92 . 93 . 94 . 95 . 96 . 97 . 98 . 99 . 100 . 101 . 102 . 103 . 104 . 105 . 106 . 107 . 108 . 109 . 110 . 111 . 112 . 113 . 114 . 115 . 116 . 117 . 118 . 119 . 120 . 121 . 122 . 123 . 124 . 125 . 126 . 127 . 128 . 129 . 130 . 131 . 132 . 133 . 134 . 135 . 136 . 137 . 138 . 139 . 140 . 141 . 142 . 143 . 144 . 145 . 146 . 147 . 148 . 149 . 150 . 151 . 152 . 153 . 154 . 155 . 156 . 157 . 158 . 159 . 160 . 161 . 162 . 163 . 164 . 165 . 166 . 167 . 168 . 169 . 170 . 171 . 172 . 173 . 174 . 175 . 176 . 177 . 178 . 179 . 180 . 181 . 182 . 183 . 184 . 185 . 186 . 187 . 188 . 189 . 190 . 191 . 192 . 193 . 194 . 195 . 196 . 197 . 198 . 199 . 200 . 201 . 202 . 203 . 204 . 205 . 206 . 207 . 208 . 209 . 210 . 211 . 212 . 213 . 214 . 215 . 216 . 217 . 218 . 219 . 220 . 221 . 222 . 223 . 224 . 225 . 226 . 227 . 228 . 229 . 230 . 231 . 232 . 233 . 234 . 235 . 236 . 237 . 238 . 239 . 240 . 241 . 242 . 243 . 244 . 245 . 246 . 247 . 248 . 249 . 250 . 251 . 252 . 253 . 254 . 255 . 256 . 257 . 258 . 259 . 260 . 261 . 262 . 263 . 264 . 265 . 266 . 267 . 268 . 269 . 270 . 271 . 272 . 273 . 274 . 275 . 276 . 277 . 278 . 279 . 280 . 281 . 282 . 283 . 284 . 285 . 286 . 287 . 288 . 289 . 290 . 291 . 292 . 293 . 294 . 295 . 296 . 297 . 298 . 299 . 300 . 301 . 302 . 303 . 304 . 305 . 306 . 307 . 308 . 309 . 310 . 311 . 312 . 313 . 314 . 315 . 316 . 317 . 318 . 319 . 320 . 321 . 322 . 323 . 324 . 325 . 326 . 327 . 328 . 329 . 330 . 331 . 332 . 333 . 334 . 335 . 336 . 337 . 338 . 339 . 340 . 341 . 342 . 343 . 344 . 345 . 346 . 347 . 348 . 349 . 350 . 351 . 352 . 353 . 354 . 355 . 356 . 357 . 358 . 359 . 360 . 361 . 362 . 363 . 364 . 365 . 366 . 367 . 368 . 369 . 370 . 371 . 372 . 373 . 374 . 375 . 376 . 377 . 378 . 379 . 380 . 381 . 382 . 383 . 384 . 385 . 386 . 387 . 388 . 389 . 390 . 391 . 392 . 393 . 394 . 395 . 396 . 397 . 398 . 399 . 400 . 401 . 402 . 403 . 404 . 405 . 406 . 407 . 408 . 409 . 410 . 411 . 412 . 413 . 414 . 415 . 416 . 417 . 418 . 419 . 420 . 421 . 422 . 423 . 424 . 425 . 426 . 427 . 428 . 429 . 430 . 431 . 432 . 433 . 434 . 435 . 436 . 437 . 438 . 439 . 440 . 441 . 442 . 443 . 444 . 445 . 446 . 447 . 448 . 449 . 450 . 451 . 452 . 453 . 454 . 455 . 456 . 457 . 458 . 459 . 460 . 461 . 462 . 463 . 464 . 465 . 466 . 467 . 468 . 469 . 470 . 471 . 472 . 473 . 474 . 475 . 476 . 477 . 478 . 479 . 480 . 481 . 482 . 483 . 484 . 485 . 486 . 487 . 488 . 489 . 490 . 491 . 492 . 493 . 494 . 495 . 496 . 497 . 498 . 499 . 500 . 501 . 502 . 503 . 504 . 505 . 506 . 507 . 508 . 509 . 510 . 511 . 512 . 513 . 514 . 515 . 516 . 517 . 518 . 519 . 520 . 521 . 522 . 523 . 524 . 525 . 526 . 527 . 528 . 529 . 530 . 531 . 532 . 533 . 534 . 535 . 536 . 537 . 538 . 539 . 540 . 541 . 542 . 543 . 544 . 545 . 546 . 547 . 548 . 549 . 550 . 551 . 552 . 553 . 554 . 555 . 556 . 557 . 558 . 559 . 5510 . 5511 . 5512 . 5513 . 5514 . 5515 . 5516 . 5517 . 5518 . 5519 . 5520 . 5521 . 5522 . 5523 . 5524 . 5525 . 5526 . 5527 . 5528 . 5529 . 5530 . 5531 . 5532 . 5533 . 5534 . 5535 . 5536 . 5537 . 5538 . 5539 . 5540 . 5541 . 5542 . 5543 . 5544 . 5545 . 5546 . 5547 . 5548 . 5549 . 5550 . 5551 . 5552 . 5553 . 5554 . 5555 . 5556 . 5557 . 5558 . 5559 . 55510 . 55511 . 55512 . 55513 . 55514 . 55515 . 55516 . 55517 . 55518 . 55519 . 55520 . 55521 . 55522 . 55523 . 55524 . 55525 . 55526 . 55527 . 55528 . 55529 . 55530 . 55531 . 55532 . 55533 . 55534 . 55535 . 55536 . 55537 . 55538 . 55539 . 55540 . 55541 . 55542 . 55543 . 55544 . 55545 . 55546 . 55547 . 55548 . 55549 . 55550 . 55551 . 55552 . 55553 . 55554 . 55555 . 55556 . 55557 . 55558 . 55559 . 55560 . 55561 . 55562 . 55563 . 55564 . 55565 . 55566 . 55567 . 55568 . 55569 . 55570 . 55571 . 55572 . 55573 . 55574 . 55575 . 55576 . 55577 . 55578 . 55579 . 55580 . 55581 . 55582 . 55583 . 55584 . 55585 . 55586 . 55587 . 55588 . 55589 . 55590 . 55591 . 55592 . 55593 . 55594 . 55595 . 55596 . 55597 . 55598 . 55599 . 555100 . 555101 . 555102 . 555103 . 555104 . 555105 . 555106 . 555107 . 555108 . 555109 . 555110 . 555111 . 555112 . 555113 . 555114 . 555115 . 555116 . 555117 . 555118 . 555119 . 555120 . 555121 . 555122 . 555123 . 555124 . 555125 . 555126 . 555127 . 555128 . 555129 . 555130 . 555131 . 555132 . 555133 . 555134 . 555135 . 555136 . 555137 . 555138 . 555139 . 555140 . 555141 . 555142 . 555143 . 555144 . 555145 . 555146 . 555147 . 555148 . 555149 . 555150 . 555151 . 555152 . 555153 . 555154 . 555155 . 555156 . 555157 . 555158 . 555159 . 555160 . 555161 . 555162 . 555163 . 555164 . 555165 . 555166 . 555167 . 555168 . 555169 . 555170 . 555171 . 555172 . 555173 . 555174 . 555175 . 555176 . 555177 . 555178 . 555179 . 555180 . 555181 . 555182 . 555183 . 555184 . 555185 . 555186 . 555187 . 555188 . 555189 . 555190 . 555191 . 555192 . 555193 . 555194 . 555195 . 555196 . 555197 . 555198 . 555199 . 555200 . 555201 . 555202 . 555203 . 555204 . 555205 . 555206 . 555207 . 555208 . 555209 . 555210 . 555211 . 555212 . 555213 . 555214 . 555215 . 555216 . 555217 . 555218 . 555219 . 555220 . 555221 . 555222 . 555223 . 555224 . 555225 . 555226 . 555227 . 555228 . 555229 . 555230 . 555231 . 555232 . 555233 . 555234 . 555235 . 555236 . 555237 . 555238 . 555239 . 555240 . 555241 . 555242 . 555243 . 555244 . 555245 . 555246 . 555247 . 555248 . 555249 . 555250 . 555251 . 555252 . 555253 . 555254 . 555255 . 555256 . 555257 . 555258 . 555259 . 555260 . 555261 . 555262 . 555263 . 555264 . 555265 . 555266 . 555267 . 555268 . 555269 . 555270 . 555271 . 555272 . 555273 . 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5552121235 . 5552121236 . 5552121237 . 5552121238 . 5552121239 . 5552121240 . 5552121241 . 5552121242 . 5552121243 . 5552121244 . 5552121245 . 5552121246 . 5552121247 . 5552121248 . 5552121249 . 5552121250 . 5552121251 . 5552121252 . 5552121253 . 5552121254 . 5552121255 . 5552121256 . 5552121257 . 5552121258 . 5552121259 . 5552121260 . 5552121261 . 5552121262 . 5552121263 . 5552121264 . 5552121265 . 5552121266 . 5552121267 . 5552121268 . 5552121269 . 5552121270 . 5552121271 . 5552121272 . 5552121273 . 5552121274 . 5552121275 . 5552121276 . 5552121277 . 5552121278 . 5552121279 . 5552121280 . 5552121281 . 5552121282 . 5552121283 . 5552121284 . 5552121285 . 5552121286 . 5552121287 . 5552121288 . 5552121289 . 5552121290 . 5552121291 . 5552121292 . 5552121293 . 5552121294 . 5552121295 . 5552121296 . 5552121297 . 5552121298 . 5552121299 . 55521212100 . 55521212101 . 55521212102 . 55521212103 . 55521212104 . 55521212105 . 55521212106 . 55521212107 . 55521212108 . 55521212109 . 55521212110 . 55521212111 . 55521212112 . 55521212113 . 55521212114 . 55521212115 . 55521212116 . 55521212117 . 55521212118 . 55521212119 . 55521212120 . 55521212121 . 55521212122 . 55521212123 . 55521212124 . 55521212125 . 55521212126 . 55521212127 . 55521212128 . 55521212129 . 55521212130 . 55521212131 . 55521212132 . 55521212133 . 55521212134 . 55521212135 . 55521212136 . 55521212137 . 55521212138 . 55521212139 . 55521212140 . 55521212141 . 55521212142 . 55521212143 . 55521212144 . 55521212145 . 55521212146 . 55521212147 . 55521212148 . 55521212149 . 55521212150 . 55521212151 . 55521212152 . 55521212153 . 55521212154 . 55521212155 . 55521212156 . 55521212157 . 55521212158 . 55521212159 . 55521212160 . 55521212161 . 55521212162 . 55521212163 . 55521212164 . 55521212165 . 55521212166 . 55521212167 . 55521212168 . 55521212169 . 55521212170 . 55521212171 . 55521212172 . 55521212173 . 55521212174 . 55521212175 . 55521212176 . 55521212177 . 55521212178 . 55521212179 . 55521212180 . 55521212181 . 55521212182 . 55521212183 . 55521212184 . 55521212185 . 55521212186 . 55521212187 . 55521212188 . 55521212189 . 55521212190 . 55521212191 . 55521212192 . 55521212193 . 55521212194 . 55521212195 . 55521212196 . 55521212197 . 55521212198 . 55521212199 . 555212121200 . 555212121201 . 555212121202 . 555212121203 . 555212121204 . 555212121205 . 555212121206 . 555212121207 . 555212121208 . 555212121209 . 555212121210 . 555212121211 . 555212121212 . 555212121213 . 555212121214 . 555212121215 . 555212121216 . 555212121217 . 555212121218 . 5552

```

1  import ee
2  from datetime import date, timedelta, datetime
3  import time
4  from google.cloud import storage
5  from google.oauth2 import service_account
6  import json
7
8  # Function to calculate NDVI and other vegetation indices for each image in a Sentinel-2 collection
9  def calculate_vegetation_indices(image):
10     # B2 = BLUE
11     # B3 = GREEN
12     # B4 = RED
13     # B5 = Visible and Near Infrared
14     # B8 = Near Infrared
15     # B11 = Short Wave Infrared
16     image = ee.Image(image.divide(10000).copyProperties(image).copyProperties(image, ['system:time_start']))
17     image = image.addBands(image.normalizedDifference(['nir', 'r']).rename('ndvi'))
18     image = image.addBands(image.normalizedDifference(['nir', 'g']).rename('gndvi'))
19     image = image.addBands(image.normalizedDifference(['g', 'r']).rename('grvi'))
20     image = image.addBands(image.select('nir').divide(image.select('g')).subtract(1).rename('cig'))
21     image = image.addBands(image.expression(
22         '2.5 * ((nir-r) / (nir + 6*r - 7.5*b + 1))', {
23             'nir': image.select('nir'),
24             'r': image.select('r'),
25             'b': image.select('b')
26         }).rename('evi'))
27     image = image.addBands(image.select('nir').gt(0).unmask(0).rename('unmasked'))
28     image = image.addBands(image.normalizedDifference(['g', 'swir1']).rename('mndwi'))
29     image = image.addBands(image.normalizedDifference(['nir', 'swir1']).rename('lswi'))
30     image = image.addBands(image.select('nir').divide(image.select('re')).subtract(1).rename('cire'))
31     return image
32
33

```

- Below the calculation of vegetation indices, is the below code from line 35 to line 61 the ‘maskS2clouds’ and ‘mask_clouds’ functions contained in the orange rectangle are used to mask clouds using the Sentinel-2 QA band in the Sentinel-2 collections; while, the code from line 64 to line 70 contained in the blue rectangle, is a function called “get_sentinel2_image_collection()” that takes in a start_date, end_date and an image collection, which it uses to select and rename relevant bands of interest to readable human values. The mask values and collections can be tweaked, and the relevant bands selected can be changed and renamed as per the interests of the user.

```

34  # Function to mask clouds using the Sentinel-2 QA band.
35  def maskS2clouds(image):
36      # The QA60 bitmask band contains information on the cloud cover for each pixel.
37      # So select this band
38      qa = image.select('QA60')
39
40      # Bits 10 and 11 are clouds and cirrus, respectively.
41      # Use zero fill left shift operators
42      cloudBitMask = 1 << 10
43      cirrusBitMask = 1 << 11
44
45      # Both flags should be set to zero, indicating clear conditions.
46      mask = qa.bitwiseAnd(cloudBitMask).eq(0) and qa.bitwiseAnd(cirrusBitMask).eq(0)
47
48      # Return the masked and scaled data, without the QA bands.
49      # The value returned is either null if clouds are obscuring the
50      # pixel or the actual value if not
51      # return image.updateMask(mask).divide(10000).select("B.*").copyProperties(image, ["system:time_start"])
52      return image.updateMask(mask)
53
54
55  def mask_clouds(img):
56      # masks clouds in Sentinel-2 collections
57      img=ee.Image(img)
58      clouds = ee.Image(img.get('cloud_mask')).select('probability')
59      isNotCloud = clouds.lt(40)
60      return img.updateMask(isNotCloud)
61
62
63  # select the relevant bands and rename to more human-readable heading values
64  def get_sentinel2_image_collection(start_date,end_date, coll='COPERNICUS/S2_HARMONIZED'):
65      sentinel2_image_collection = ee.ImageCollection(coll) \
66          .filterDate(start_date,end_date) \
67          .select(['B2','B3','B4','B5','B8','B6','B7','B8A','B11','B12','QA60'], ['b','g','r','re','nir','re74','re78','re86','swir1','swir2','QA60'])
68
69      sentinel2_cloud_probability = ee.ImageCollection('COPERNICUS/S2_CLOUD_PROBABILITY')\
70          .filterDate(start_date,end_date)
71

```

- Below, the Mask cloud, collection selection-and-renaming functions, are the below functions:

The “get_timeseries_feature_collection()” function highlighted within the yellow rectangle in the below image that spans code from line 81 to line 97 is used to get the time series over the feature collection, then return the image collection sample images. It takes in a ‘feature collection’, image collection, jsonfile (geojson) image properties, and scale as arguments.

The function below the “get_timeseries_feature_collection()” function is the “add_date_to_image()” function highlighted in the green rectangle in the image below, which takes in an image as an argument and allows the user to choose a date format and add the corresponding dates to the images.

Both of these functions allow changes to be made to the arguments passed in, the scale of the images and the date format of the date that is appended to the images

```

71     sentinel2_image_collection = ee.Join.saveFirst('cloud_mask').apply(**{
72         'primary': sentinel2_image_collection,
73         'secondary': sentinel2_cloud_probability,
74         'condition': ee.Filter.equals(leftField='system:index', rightField='system:index')
75     })
76     return ee.ImageCollection(sentinel2_image_collection).map(maskS2clouds).map(calculate_vegetation_indices)
77
78
79
80     #get time series over a feature collection, general, doesn't filter ic
81     def get_timeseries_feature_collection(feature_collection,image_collection,json_file,image_props=[],scale=10):
82         def get_time_series_single_feature(feature):
83             geom = feature.geometry();
84             def sample_image(image):
85                 return feature.set(image.reduceRegion(**{'reducer':ee.Reducer.mean(),'geometry':geom, 'scale':scale})) \
86                     .setGeometry(geom.centroid(10)) \
87                     .set(image.toDictionary(image_props)) \
88                     .set('area_gee',geom.area(1).divide(10000)) \
89                     .set('geojson_filename',json_file)
90             samples = image_collection.map(sample_image)
91             return samples
92
93         #get time series for a single feature
94         time_series = feature_collection.map(get_time_series_single_feature)
95
96         #will be a collection of collections, so need to flatten to a collection
97         return time_series.flatten()
98
99
100    def add_date_to_image(image):
101        tz = 'Australia/Sydney'
102        date = ee.Date(image.get('system:time_start'))
103        au_formatted_date = date.format(**{'format':'yyyy-MM-dd','timeZone':tz})
104        return image.set({
105            'date':au_formatted_date,
106        });
107

```

The “main_function” function handles the initialization of the service account and private key, it also contains the setting for the timeframe or time period from which CropWatch will collect data within, it includes the loading of the geojson file to obtain the farm details from, and finally; a function to add a description, set an output destination (databucket), and define the file format of the export (in this case ‘.csv’).

Line 109 to line 116, is where the service account and private key for the project is initialized. - This can be edited to initialize another project and another private key if needed.

```

109    def main_function(request):
110        #initialize earth engine using json key for service account
111        service_account = 'google-earth-engine-service-ac@aarsc-2022-compsciprac.iam.gserviceaccount.com'
112        privateKey = 'sa-private-key.json'
113
114        # authenticate using service account
115        credentials = ee.ServiceAccountCredentials(service_account, privateKey)
116        ee.Initialize(credentials)
117

```

Line 119 -120 includes a variable called “start_date”, which sets the start of the timeframe for the Google Earth images data. And “end_date” which determines the most current date you want the function to retrieve data up to to end the timeframe of data collection of interest.

```
116     # set the start and end dates for the code
117     # this should be moved to arguments in the future
118     # start with a 2 year timeframe (730 days)
119     start_date = (date.today() - timedelta(days=730)).strftime("%Y-%m-%d")
120     end_date = date.today().strftime("%Y-%m-%d")
121
```

“start_date” is currently set in this screenshot to today minus 730 days (2 years) but can be adjusted to any other value. The currently deployed, default adjusted value was set to 1095 days (3 years) as can be seen in the screenshot below:

```
128     # set the start and end dates for the code
129     # this should be moved to arguments in the future
130     # start with a 3 year timeframe (1095 days)
131     start_date = (date.today() - timedelta(days=1095)).strftime("%Y-%m-%d")
132     end_date = date.today().strftime("%Y-%m-%d")
```

Hence; 3 years of data from the current date can be obtained and exported by CropWatch’s farm-calculator function.

The code on *line 118 to line 126*, provides the option to get an optional POST argument for the json file name is available:

```
118     # get optional POST argument for the json filename
119     request_json = request.get_json(silent=True)
120     request_args = request.args
121     if request_json and 'json_filename' in request_json:
122         json_filename = request_json['json_filename']
123     elif request_args and 'json_filename' in request_args:
124         json_filename = request_args['json_filename']
125     else:
126         json_filename = 'farm_details.json'
```

The code on *line 134 to line 138*, allows the loading of the geojson file that is passed into the previous argument.

```

134     # load a geojson file to get farm details
135     # json_filename = 'farm_details.json'
136     json_file = open(json_filename)
137     feature_collection_json = json.load(json_file)
138     json_file.close()

```

The code on line 140 to line 151, handles the creation of the feature collection based on the geojson data supplied from the geojson file, the farm boundaries are then extracted from this feature collection and used in combination with Sentinel2 satellite images within the earlier supplied date range (start_date, end_date), then the image statistics at each time over each defined in the feature collection, is obtained.

```

140     # create the feature collection based on the geojson supplied
141     feature_collection = ee.FeatureCollection(feature_collection_json)
142
143     # extract the farm boundaries from the feature collection
144     geom = feature_collection.geometry().bounds()
145
146     # create an image collection from the sentinel2 satellite images using the date ranges and geo boundaries
147     # - collection of S2 images covering the feature collection of interest
148     sentinel2_image_collection = get_sentinel2_image_collection(start_date,end_date).filterBounds(geom).map(add_date_to_image)
149
150     #gets image statistics at each time over each field defined in feature collection
151     time_series = get_timeseries_feature_collection(feature_collection,sentinel2_image_collection,json_filename,image_props=['date','ndvi','gndvi','grvi','cig','mndwi','lswi','cire'],scale=10)

```

The code on line 156 sets the description field for the data export. The system utilizes this field to set the name of the exported CSV file. It is currently set to farm_data_export_[current date/time]; however, this can be changed to any other value.

The code from line 154 to line 163 is utilized to add a description field for the data being exported, set an output destination (databucket), and define the file format of the export (in this case ‘.csv’) as can be observed below:

```

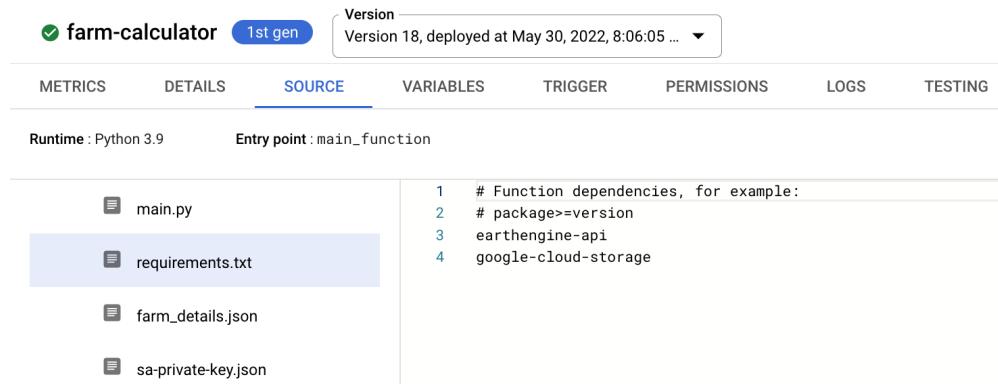
153     # Function to export statistical values per ID with the information of day, month and year
154     task = ee.batch.Export.table.toCloudStorage(
155         collection=time_series,
156         description='farm_data_export_'+str(datetime.now().year) + "-" + str(datetime.now().month) + "-" + str(datetime.now().day) + " " + str(datetime.now().hour) + ":" + str(datetime.now().minute),
157         outputBucket='aarsc-2022-compsciprac-csv-databucket',
158         fileFormat='csv',
159         #selectors=['date','id','ndvi','gndvi','grvi','cig','mndwi','lswi','cire']
160     )
161     task.start()
162
163     return "completed"
164

```

- Once the file is exported, the filename is set and exported to the databucket as: ‘farm_data_export_[date and time of the export]’ in a ‘.csv’ format.

The other documents within the farm-calculator are as follows:

- **Requirements.txt** – This file sets out the relevant dependencies for the Python code. Currently, the code relies on the Google Earth Engine API and Google Cloud Storage



farm-calculator 1st gen Version Version 18, deployed at May 30, 2022, 8:06:05 ...

METRICS DETAILS SOURCE VARIABLES TRIGGER PERMISSIONS LOGS TESTING

Runtime : Python 3.9 Entry point : main_function

main.py requirements.txt farm_details.json sa-private-key.json

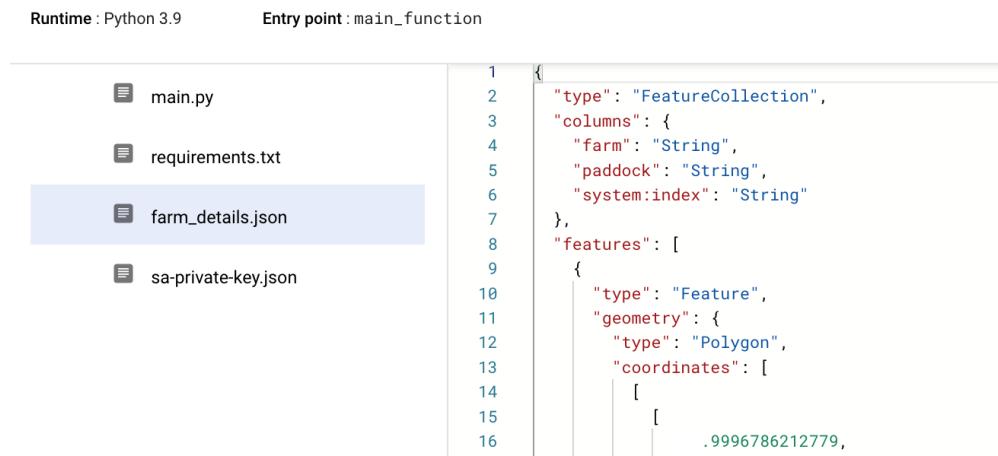
```

1 # Function dependencies, for example:
2 # package>=version
3 earthengine-api
4 google-cloud-storage

```

- **Farm_details.json** – This file sets out the boundaries of the farms to be examined with the code. This file contains GeoJSON data saved in JSON format.

Coordinates redacted example:



Runtime : Python 3.9 Entry point : main_function

main.py requirements.txt farm_details.json sa-private-key.json

```

1 {
2   "type": "FeatureCollection",
3   "columns": {
4     "farm": "String",
5     "paddock": "String",
6     "system:index": "String"
7   },
8   "features": [
9     {
10       "type": "Feature",
11       "geometry": {
12         "type": "Polygon",
13         "coordinates": [
14           [
15             [
16               [
17                 [
18                   [
19                     [
20                     [
21                     [
22                     [
23                     [
24                     [
25                     [
26                     [
27                     [
28                     [
29                     [
30                     [
31                     [
32                     [
33                     [
34                     [
35                     [
36                     [
37                     [
38                     [
39                     [
40                     [
41                     [
42                     [
43                     [
44                     [
45                     [
46                     [
47                     [
48                     [
49                     [
50                     [
51                     [
52                     [
53                     [
54                     [
55                     [
56                     [
57                     [
58                     [
59                     [
59

```

The screenshot shows the Google Cloud Functions console for the 'farm-calculator' function. The 'SOURCE' tab is active. The code structure on the left shows 'main.py', 'requirements.txt', 'farm_details.json' (which is highlighted in blue), and 'sa-private-key.json'. The code preview on the right shows lines 38 to 55 of 'main.py'. The code is a JSON object representing a FeatureCollection with one feature, 'f1', which has an id of '0' and a property 'paddock' of 'p1'. The geometry is a polygon with coordinates.

```

38   ],
39   ],
40   ],
41   },
42   "id": "0",
43   "properties": {
44     "farm": "f1",
45     "paddock": "p1"
46   },
47   {
48     "type": "Feature",
49     "geometry": {
50       "type": "Polygon",
51       "coordinates": [
52         [
53           [
54             [
55               [

```

To examine a different set of farms, this file can be either replaced with another valid FeatureCollection in JSON format or adjustments to the python code on line 123, within the main function can be made.

“

- **Sa-private-key** – This file provides the private key for the service account used to run the Python code. If a different service account is used, this file will need to be updated.” - Steve

Tip : This “Sa-private-key” file, is a confidential file of which its contents cannot be shown to non-members of the team and should not be uploaded to the open source github repository.

There are a number of ways to run the cloud function:

1. Use the HTTP trigger URL (<https://australia-southeast1-aarsc-2022-compsciprac.cloudfunctions.net/farm-calculator>). Permissions are required to run the function this way; otherwise, access will be denied.
2. Open the function, select the ‘Testing’ tab and then click the ‘Test the Function’ button .

- Below is what shows up when the task is completed

- Next, navigate to the cloud storage (databucket) by clicking the menu icon at the top left of the page, next to “Google Cloud Platform” header, then scroll down to the “Storage” section and click on “Cloud Storage”, then “browse”:

Google Cloud Platform sidebar:

- Security
- Anthos
- COMPUTE
 - Compute Engine
 - Kubernetes Engine
 - VMware Engine
 - Distributed Cloud
- SERVERLESS
 - Cloud Run
 - Cloud Functions
 - App Engine
- STORAGE
 - Filestore
 - Cloud Storage
 - Data Transfer
- DATABASES

Context menu (open over 'Cloud Storage'):

- Browser
- Monitoring
- Settings

- This will load the cloud storage page which will have the databucket that is being used within the project at the top of the list (only selected below for reference purposes), click on it:

Google Cloud Platform Cloud Storage Browser page:

Cloud Storage sidebar:

- Browser
- Monitoring
- Settings

Top navigation bar:

- CREATE BUCKET
- DELETE
- REFRESH

Table (List of buckets):

| Name | Created | Location type | Location | Default storage class | Last modified | Public access | Access control | Protection |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| aarsc-2022-compsciprac-csv-database | Apr 30, 2022, 4:21:54 PM | Region | australia-southeast1 | Standard | Apr 30, 2022, 4:21:54 PM | Not public | Uniform | None |
| asia.artifacts.aarsc-2022-compsciprac | Apr 6, 2022, 8:32:40 PM | Multi-region | asia | Standard | Apr 6, 2022, 8:32:40 PM | Subject to object ACLs | Fine-grained | None |
| gcf-sources-110895979228-australia... | Apr 6, 2022, 8:31:55 PM | Region | australia-southeast1 | Standard | Apr 6, 2022, 8:31:55 PM | Not public | Uniform | None |
| gcf-sources-110895979228-us-central1 | Mar 23, 2022, 8:01:42 AM | Region | us-central1 | Standard | Mar 23, 2022, 8:01:42 AM | Not public | Uniform | None |
| loc000 | Mar 15, 2022, 8:55:51 AM | Region | australia-southeast1 | Standard | Mar 15, 2022, 8:55:51 AM | Not public | Uniform | None |
| us.artifacts.aarsc-2022-compsciprac... | Mar 23, 2022, 8:02:11 AM | Multi-region | us | Standard | Mar 23, 2022, 8:02:11 AM | Subject to object ACLs | Fine-grained | None |

- The page that loads has the most current exported data (only selected below for reference purposes) (based on service usage, the time it takes to appear in the cloud storage might vary, based on if you are exporting at peak hours and or if your internet connection is not as fast):

Google Cloud Platform - aarsc-2022-compsciprac - Bucket details

aarsc-2022-compsciprac-csv-databucket

| Location | Storage class | Public access | Protection |
|-------------------------------|---------------|---------------|------------|
| australia-southeast1 (Sydney) | Standard | Not public | None |

OBJECTS **CONFIGURATION** **PERMISSIONS** **PROTECTION** **LIFECYCLE**

Buckets > aarsc-2022-compsciprac-csv-databucket

UPLOAD FILES UPLOAD FOLDER CREATE FOLDER MANAGE HOLDS DOWNLOAD DELETE

Filter by name prefix only Filter objects and folders

| Name | Size | Type | Created | Storage class | Last modified | Public access | Version history | Encryption | Retention |
|---|--------|----------|--------------|---------------|---------------|---------------|-----------------|--------------------|-----------|
| <input checked="" type="checkbox"/> farm_data_export_2022-6-11 9:51.csv | 2.2 MB | text/csv | Jun 11, 2022 | Standard | Jun 11, 2022 | Not public | — | Google-managed key | — |
| <input type="checkbox"/> farm_data_export_2022-6-4 9:51.csv | 2.2 MB | text/csv | Jun 4, 2022 | Standard | Jun 4, 2022 | Not public | — | Google-managed key | — |

Show deleted data

Clicking on the file, shows further information about the file as can be seen below, and provides the option to edit access, change metadata, delete the file or to download the file:

Google Cloud Platform - aarsc-2022-compsciprac - Object details

Object details

Buckets > aarsc-2022-compsciprac-csv-databucket > **farm_data_export_2022-6-11 9:51.csv**

LIVE OBJECT VERSION HISTORY

DOWNLOAD **EDIT METADATA** **EDIT ACCESS** **DELETE**

Overview

| | |
|-------------------|---|
| Type | text/csv |
| Size | 2.2 MB |
| Created | Jun 11, 2022, 8:00:22 PM |
| Last modified | Jun 11, 2022, 8:00:22 PM |
| Storage class | Standard |
| Custom time | — |
| Public URL | Not applicable |
| Authenticated URL | https://storage.cloud.google.com/aarsc-2022-compsciprac-csv-databucket/farm_data_export_2022-6-11%209%3A51.csv?authuser=2 |
| gsutil URI | gs://aarsc-2022-compsciprac-csv-databucket/farm_data_export_2022-6-11 9:51.csv |

Permissions

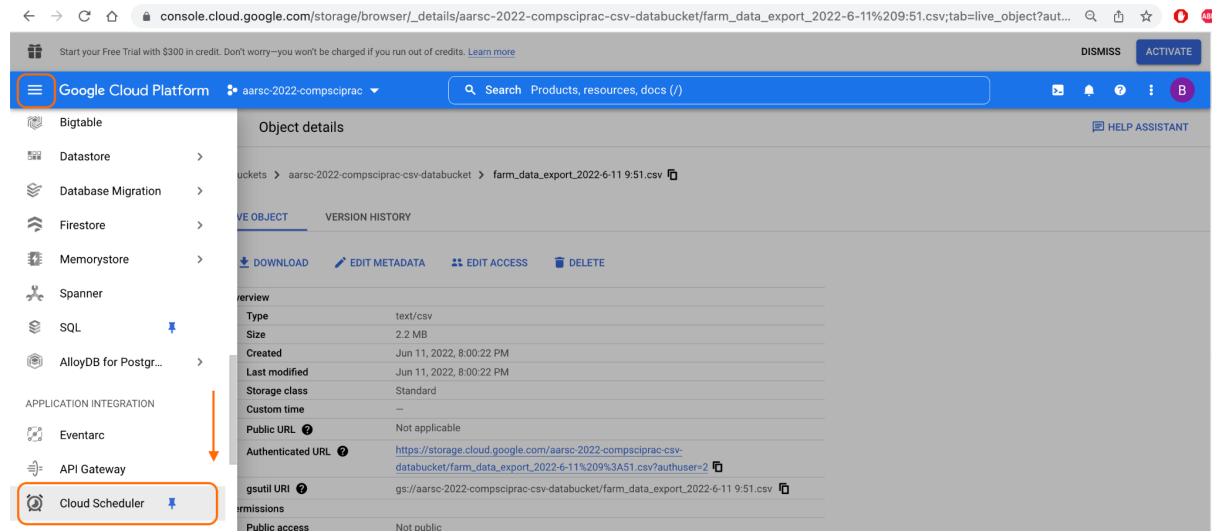
| | |
|---------------|------------|
| Public access | Not public |
|---------------|------------|

Protection

| | |
|------------------|--------------------|
| Hold status | None |
| Version history | — |
| Retention policy | None |
| Encryption type | Google-managed key |

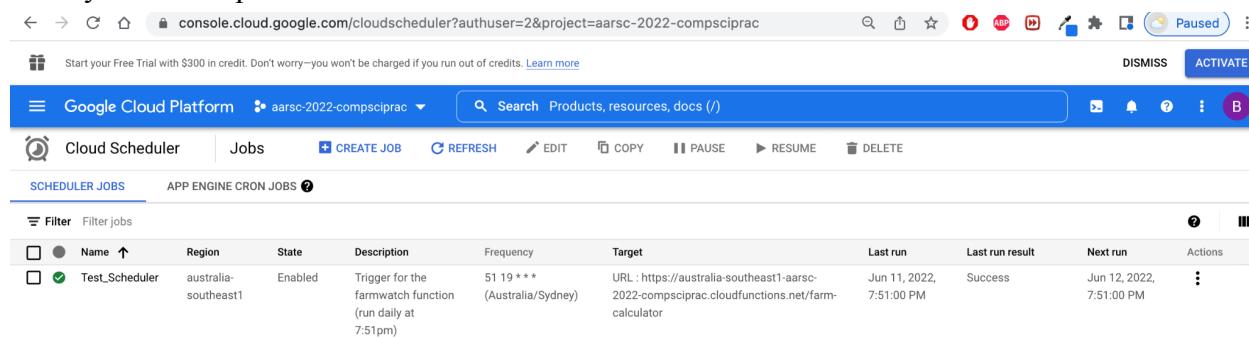
3. Run the job through the Google Cloud Scheduler. A scheduled task has been set up to run the function daily; however, the scheduler will also allow a manual trigger of the task by clicking the ‘Run Now’ button.

- Click on the menu icon at the top left of the page, next to “Google Cloud Platform” header, then scroll down to the “Application Integration” section and click on “Cloud Scheduler”:



The screenshot shows the Google Cloud Platform Storage browser interface. The left sidebar lists various services: Bigtable, Datastore, Database Migration, Firestore, Memorystore, Spanner, SQL, and AlloyDB for PostgreSQL. Below these, under 'APPLICATION INTEGRATION', are Eventarc and API Gateway. At the bottom of the sidebar, 'Cloud Scheduler' is highlighted with a red box and an arrow pointing down to the main content area. The main content area shows 'Object details' for the file 'farm_data_export_2022-6-11 9:51.csv'. The 'OVERVIEW' section includes fields like Type (text/csv), Size (2.2 MB), Created (Jun 11, 2022, 8:00:22 PM), and Last modified (Jun 11, 2022, 8:00:22 PM). It also shows Public URL and Authenticated URL.

- Next, the page loads up and shows the aforementioned existing schedule that has already been set up:



The screenshot shows the Google Cloud Platform Cloud Scheduler interface. The top navigation bar includes 'Google Cloud Platform', 'aarsc-2022-compsciprac', a search bar, and 'DISMISS ACTIVATE' buttons. Below the navigation is a toolbar with 'CREATE JOB', 'REFRESH', 'EDIT', 'COPY', 'PAUSE', 'RESUME', and 'DELETE' buttons. The main area is titled 'SCHEDULER JOBS' and shows a table of scheduled jobs. The table has columns: Name, Region, State, Description, Frequency, Target, Last run, Last run result, Next run, and Actions. One row is highlighted with a red box: 'Test_Scheduler' (Region: australia-southeast1, State: Enabled, Description: Trigger for the farmwatch function (Australia/Sydney), Frequency: 51 19 * * *, Target: URL: https://australia-southeast1-aarsc-2022-compsciprac.cloudfunctions.net/farm-calculator). The 'Last run' column shows 'Jun 11, 2022, 7:51:00 PM' and 'Success'. The 'Next run' column shows 'Jun 12, 2022, 7:51:00 PM'.

- Changes can be made to this schedule by clicking on it and making adjustments to the parameters below, please observe that the cloud scheduler in this “test_schedule” is currently set to trigger and run the CropWatch farm-calculator function every day at 7:51 pm, AEST (Australian Eastern Standard Time):

The screenshot shows the Google Cloud Platform Cloud Scheduler interface. At the top, the navigation bar includes the Google Cloud Platform logo, the project name 'aarsc-2022-compsciprac', and a search icon. Below the navigation bar, the 'Cloud Scheduler' logo and the name 'Test_Scheduler' are displayed, with a back arrow icon to its left. The main content area is titled 'Define the schedule' and contains the following fields:

- Region:** australia-southeast1
- Description:** Trigger for the farmwatch function (run daily at 7:51pm)
- Frequency ***: 51 19 * * *

Schedules are specified using unix-cron format. E.g. every minute: "* * * * *", every 3 hours: "0 */3 * * *", every monday at 9:00: "0 9 * * 1". [Learn more](#)

- Timezone ***: Australian Eastern Standard Time (AEST)

Below the configuration fields, there is a 'CONTINUE' button. At the bottom of the page, there are 'UPDATE' and 'CANCEL' buttons.

- The current execution configuration of the cloud scheduler is displayed below, and can be adjusted as pleased:

Google Cloud Platform aarsc-2022-compscicrac Test_Scheduler

Configure the execution

Target type * HTTP

URL * https://australia-southeast1-aarsc-2022-compscicrac.cloudfunctions.net/farm-

HTTP method POST

HTTP headers

Some headers are set to default values or removed by Cloud Scheduler. [Learn more](#)

Name 1 * User-Agent Value 1 Google-Cloud-Scheduler

+ ADD A HEADER

Body

Auth header Add OIDC token

Service account * Google Earth Engine Service Account SD

This service account must have permission to invoke the target. For example, the Cloud Functions Invoker role is required to schedule a Cloud Function. [Learn more](#)

Audience https://australia-southeast1-aarsc-2022-compscicrac.cloudfunctions.net/farm-

Audience limits recipients for the OIDC token. Typically, the job's target URL (without any url parameters). If not specified, by default, Cloud Scheduler will use the whole URL, including request parameters, as the Audience.

CONTINUE

- The optional settings that handle the retrying of the scheduled function in the event of a job not completing successfully are shown below; and can be adjusted as pleased:

Google Cloud Platform aarsc-2022-compsciprac

Cloud Scheduler Test_Scheduler

Audience limits recipients for the OIDC token. Typically, the job's target URL (without any url parameters). If not specified, by default, Cloud Scheduler will use the whole URL, including request parameters, as the Audience.

CONTINUE

Configure optional settings

Retry config

If a job does not complete successfully, it is retried, with exponential backoff, according to the settings in retry config. [Learn more](#)

Max retry attempts: 0

Maximum number of retry attempts for a failed job

Max retry duration: 0s

Time limit for retrying a failed job, 0s means unlimited

Min backoff duration: 5s

Maximum time to wait before retrying a job after it fails

Max backoff duration: 1h

Maximum time to wait before retrying a job after it fails

Max doublings: 5

The time between retries will double max doublings times

Attempt deadline config

Attempt deadline: 3m

Leave empty to reset duration to the default 3 minutes.

UPDATE CANCEL

- To create a new job; click on the “Cloud Scheduler” tab at the top left of the page, then click on the “Create Job” tab located at the top, near the middle of the page:

Google Cloud Platform aarsc-2022-compsciprac

Cloud Scheduler Jobs + CREATE JOB

SCHEDULER JOBS APP ENGINE CRON JOBS

Filter Filter jobs

| | Name | Region | State | Description | Frequency | Target | Last run | Last run result | Next run | Actions |
|--------------------------|----------------|----------------------|---------|--|-------------|---|--------------------------|-----------------|--------------------------|---------|
| <input type="checkbox"/> | Test_Scheduler | australia-southeast1 | Enabled | Trigger for the farmwatch function (run daily at 7:51pm) | 51 19 * * * | URL: https://australia-southeast1-aarsc-2022-compsciprac.cloudfunctions.net/farm-calculator | Jun 11, 2022, 7:51:00 PM | Success | Jun 12, 2022, 7:51:00 PM | |

- Next you will be provided an empty form to fill in the parameters with required information to create the scheduled job (**Please note that:** an example of the

required information needed, has already been shown in the above steps within the above existing scheduled job named “Test_Scheduler”):

Google Cloud Platform aarsc-2022-compsciprac Cloud Scheduler Create a job

- **Define the schedule**
 - Name *
 - Region *
 - Description
 - Frequency *
 - Timezone *
- **Configure the execution**
- **Configure optional settings**

CONTINUE

CREATE CANCEL

This concludes the options and processes directly related with the cloud-function.

CropWatch: Exporting farm data to the Database (BigQuery)

After data gets exported from the CropWatch farm-calculator's Main.py script's main function into the "Aarsc-2022-compsciprac-csv-databucket", the project's Google Cloud Storage Bucket; the below processes commence:

“

Daily Data Transfer from the Databucket

A daily Goggle Data Transfer called "Daily Load 2" runs at 1:00 AM AEST and transfers all files that meet the following criteria

gs://aarsc-2022-compsciprac-csv-databucket/farm_data_export_*.csv to table

`'aarsc-2022-compsciprac.aarsc_import_data.Daily_Import2'`

All files that meet the file name criteria are appended to the Daily_Import2 table. At this point there are no checks for duplicates carried out on the files.

Details of this transfer can be amended by clicking on the transfer, then Configuration / Edit. In this section you can select for the files not to be deleted after processing. This can be done by clicking the data transfer, clicking on Configuration/Edit and then clicking off the Delete Source Files on Transfer button. Note that if you wish to reprocess the files you will need to rename them prior to reprocessing. The timing of the transfer as well as some of the file configuration details can be altered in this section.

Every day at 1:00 AM Australia/Sydney

Destination settings

Select the destination for the transfer data

Dataset * aarsc_import_data

Data source details

Destination table Daily_Import2

Cloud Storage URI aarsc-2022-compsciprac-csv-databucket/farm_data_export_*.c BROWSE

Write preference APPEND

Delete source files after transfer

File format * CSV

The data transfer can be run on demand by selecting the data transfer and then selecting Run Transfer now at the top right of the screen.

| Transfer details | | RUN HISTORY | CONFIGURATION | EDIT | DELETE | DISABLE | RUN TRANSFER NOW | MORE |
|--|-----------------------------------|-----------------------------------|---------------|--|--------|---------|------------------|------|
| ✓ Daily Load 2 | | | | | | | | |
| Schedule (UTC) Target date for next run | | | | | | | | |
| every day 15:00 | June 5, 2022 at 1:00:00 AM UTC+10 | | | | | | | |
| <input type="button" value="Filter"/> Filter transfer runs | | | | | | | | |
| Run date | Run time | Schedule time | UTC+10 | Summary | | | | |
| June 3, 2022 | June 4, 2022 at 1:00:00 AM UTC+10 | June 4, 2022 at 1:00:00 AM UTC+10 | | The transfer run has completed successfully. | | | | |
| June 2, 2022 | June 3, 2022 at 1:00:00 AM UTC+10 | June 3, 2022 at 1:00:00 AM UTC+10 | | The transfer run has completed successfully. | | | | |
| June 1, 2022 | June 2, 2022 at 1:00:00 AM UTC+10 | June 2, 2022 at 1:00:00 AM UTC+10 | | The transfer run has completed successfully. | | | | |
| May 31, 2022 | June 1, 2022 at 1:00:00 AM UTC+10 | June 1, 2022 at 1:00:00 AM UTC+10 | | The transfer run has completed successfully. | | | | |
| May 30, 2022 | May 31, 2022 at 1:00:00 AM UTC+10 | May 31, 2022 at 1:00:00 AM UTC+10 | | The transfer run has completed successfully. | | | | |
| May 29, 2022 | May 30, 2022 at 8:06:42 AM UTC+10 | May 30, 2022 at 8:06:42 AM UTC+10 | | The transfer run has completed successfully. | | | | |
| May 29, 2022 | May 30, 2022 at 1:00:00 AM UTC+10 | May 30, 2022 at 1:00:00 AM UTC+10 | | The transfer run has completed successfully. | | | | |
| May 29, 2022 | May 29, 2022 at 7:04:06 PM UTC+10 | May 29, 2022 at 7:04:06 PM UTC+10 | | The transfer run has completed successfully. | | | | |
| May 29, 2022 | May 29, 2022 at 6:57:38 PM UTC+10 | May 29, 2022 at 6:57:38 PM UTC+10 | | The transfer run has completed successfully. | | | | |
| May 29, 2022 | May 29, 2022 at 6:12:11 PM UTC+10 | May 29, 2022 at 6:12:11 PM UTC+10 | | The transfer run has completed successfully. | | | | |

Scheduled Daily SQL

At 2:00 AM each day a scheduled SQL query runs, DailySatelliteDataLoad. It does the following:

- Selects unique records (based on farm, paddock, date and geojson_filename) in the Daily_Import file to copy to the Daily_Import_sorted file. Where duplicates exist the record with the highest ndvi record is selected.
- For each record in the Daily_Import_sorted table a check is done to see if a record with the same farm, paddock, date and geojson_filename exists in the SatelliteDataDB table. If a record exists and the ndvi is less than the ndvi in the Daily_Import_sorted table an update is made to SatelliteDataDB to include the values for the record with the higher ndvi from Daily_Import_sorted
- For each record in the Daily_Import_sorted table if a record with the same farm, paddock, date and geojson_filename doesn't exist the record is added to the SatelliteDataDB table
- The content from both


```
'aarsc-2022-compsciprac.aarsc_import_data.Daily_Import'  
'aarsc-2022-compsciprac.aarsc_import_data.Daily_Import_sorted'
```

 is deleted in preparation for the following nightly run

The scheduled query can be run on demand by selecting the query and then clicking on Schedule Backfill in the top right hand corner of the screen

Google Cloud Platform aarsc-2022-compsciprac

Scheduled query details

RUN HISTORY

CONFIGURATION

EDIT **DELETE** **DISABLE** **SCHEDULE BACKFILL** **MORE**

⌚ DailySatelliteDataLoad

Schedule (UTC) Target date for next run
every day 16:00 June 6, 2022 at 2:00:00 AM UTC+10

Filter transfer runs

| Run date | Schedule time | Summary |
|----------|---------------|--------------------|
| ● | UTC+10 | No rows to display |

The underlying SQL can also be run manually by selecting the ImportNonDupDataRecords within the BigQuery database. By highlighting the section of the SQL to be run and clicking on Run at the top the SQL can be run in sections.

Google Cloud Platform aarsc-2022-compsciprac

Explorer + ADD DATA

Monthly...ble ImportN... rds

RUN **SAVE** **SHARE** **SCHEDULE** **MORE**

```
1 # Add records from the Daily_Import file to Daily_Import_sorted
2 # Query selects unique records only and takes the record with the highest NDVI record for the given
3 # farm, paddock and date
4 insert into `aarsc-2022-compsciprac.aarsc_import_data.Daily_Import_Sorted`
5 select *
6 from
7 (select *, row_number() over (partition by farm, paddock, date, geojson_filename order by ndvi desc) as N
8 from
9 `aarsc-2022-compsciprac.aarsc_import_data.Daily_Import2`)
10 where N = 1;
11
12
13 # Code to update the SatelliteDataDB table if a record in the Daily_Import_Sorted table
14 # has a higher NDVI than an existing record in the table with the same farm, paddock and date values
15 update `aarsc-2022-compsciprac.aarsc_data.SatelliteDataDB` T1
16 set
17 T1.QA60 = T2.QA60
18 , T1.b = T2.b
19 , T1.cig = T2.cig
```

Please note that: changes made to the underlying SQL do not get passed through to the schedule query. To update the scheduled query you will need to create a new scheduled query by clicking on Schedule / Create new Schedule. You will also need to ensure that the data location is consistent with where the data is currently being stored, in this case australia-southeast1 (Sydney).

New scheduled query

Destination for query results

Set a destination table for query results

Dataset

Table Id

Destination table partitioning field

Destination table write preference

Append to table

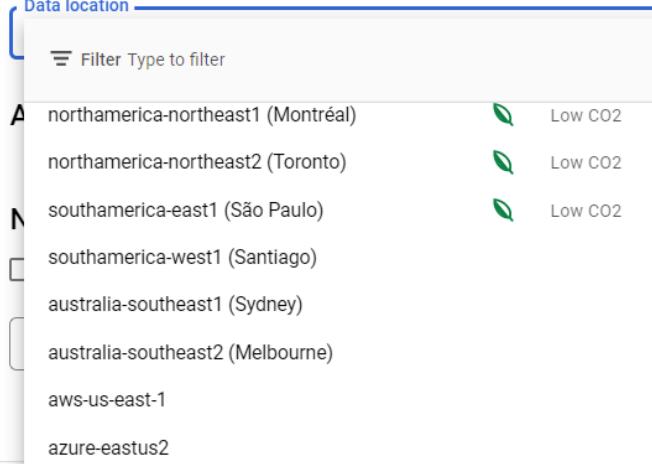
Overwrite table

Data location

Filter Type to filter

| Region | Location | CO2 Rating |
|--------|------------------------------------|------------|
| A | northamerica-northeast1 (Montréal) | Low CO2 |
| | northamerica-northeast2 (Toronto) | Low CO2 |
| N | southamerica-east1 (São Paulo) | Low CO2 |
| | southamerica-west1 (Santiago) | |
| | australia-southeast1 (Sydney) | |
| | australia-southeast2 (Melbourne) | |
| | aws-us-east-1 | |
| | azure-eastus2 | |

SAVE CANCEL



Scheduled Monthly SQL

At 3am on the 4th day of each month a monthly scheduled SQL is run called MonthlySummaryUpdate. This process deletes the content of the MonthlySatelliteDataSummary table and recreates it based on the data available in the SatelliteDataDB table. The summary table contains monthly averages, minimums and maximums, standard deviation and the upper and lower 95% confidence intervals for each of the indices in Satellite Data DB by farm, paddock and geojson_filename." - Zoe

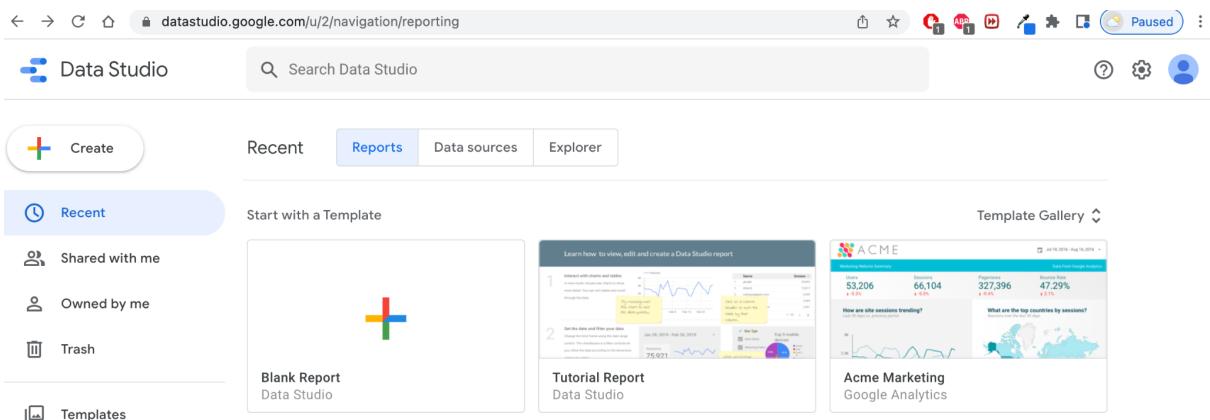
CropWatch: Visualizing Database information in DataStudio

Google DataStudio process

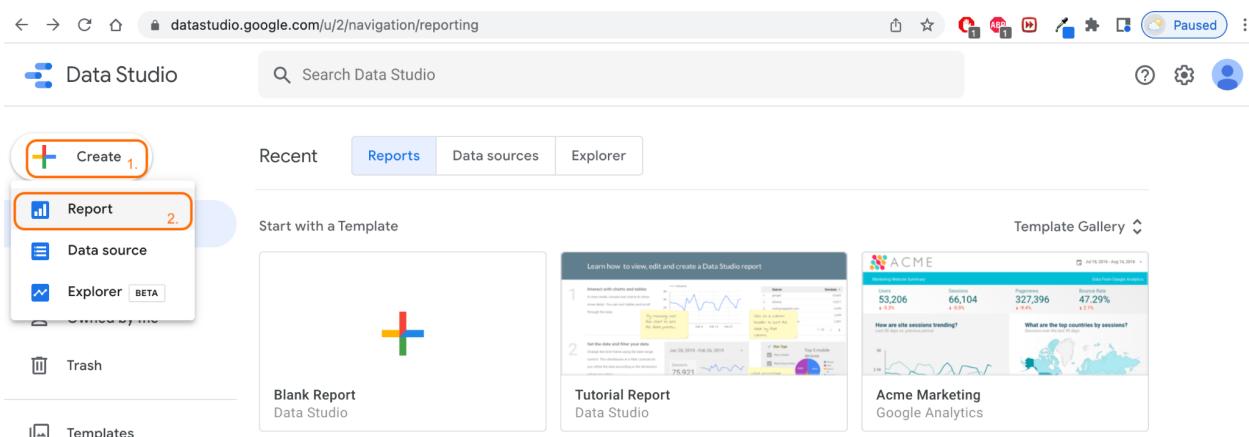
The end product of the CropWatch application process is to create reports that construct visual representations of the data collected and processed, to provide farmers valuable insights on the crop biomass and crop health of the crops in their paddocks/ farms over a given period of time up to 3 years from the current date.

The following steps should be followed to create these visual representations of the data collected and processed:

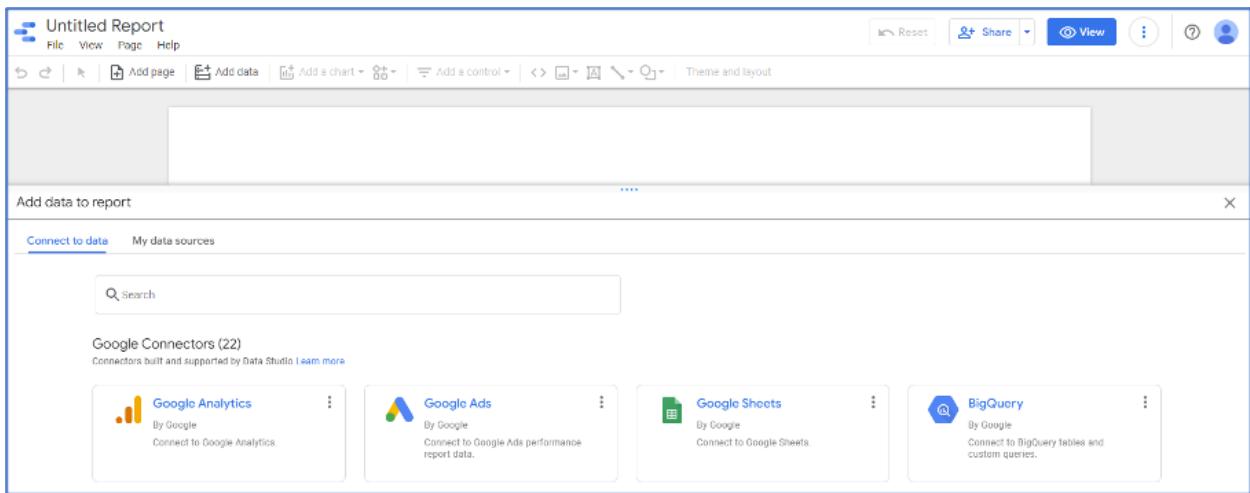
1. Go to <https://datastudio.google.com/>



2. Click on 'Create', then select 'Report':



3. Add data to report, choose 'connect to data', then click on 'BigQuery'.



4. The select project 'aarsc-2022-compsciprac' 'aarsc_data' 'MonthlySatelliteDataSummary' and 'SatelliteDataDB'

A screenshot of the 'Add data to report' dialog for BigQuery. At the top, there's a message: '⚡ Make your BigQuery reports load even faster with BigQuery BI Engine. [Learn More](#)'. Below this, the 'BigQuery' connector is selected, indicated by a blue hexagon icon. The text 'By Google' and a brief description of BigQuery as a managed data warehouse are shown. Below the connector details, there are two buttons: 'LEARN MORE' and 'REPORT AN ISSUE'. The main area is a table titled 'RECENT PROJECTS' with columns for 'Project', 'Dataset', and 'Table'. The table data is as follows:

| RECENT PROJECTS | Project | Dataset | Table |
|-----------------|------------------------------|-------------------|-----------------------------|
| MY PROJECTS | Enter Project Id manually | aarsc_data | MonthlySatelliteDataSummary |
| SHARED PROJECTS | aarsc-2022-compsciprac | aarsc_import_data | SatelliteDataDB |
| CUSTOM QUERY | Earth Engine default project | | |
| PUBLIC DATASETS | My First Project | | |
| | My Project | | |

" - Ling

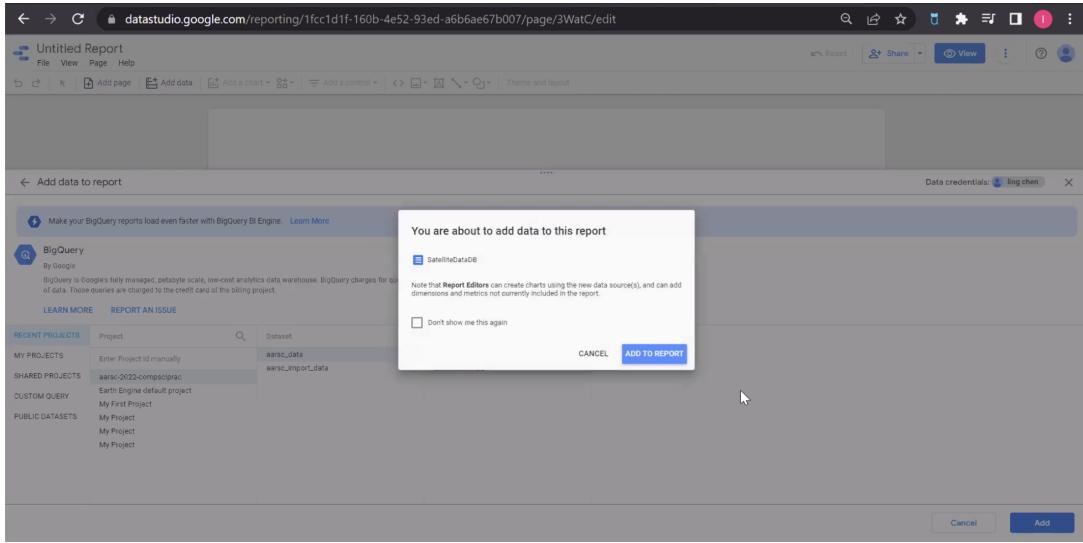
When the report is created, if the below is shown, click on the “Add data” tab at the top:

The screenshot shows the Google Data Studio interface for creating a report. The top navigation bar includes 'File', 'Edit', 'View', 'Insert', 'Page', 'Arrange', 'Resource', and 'Help'. The 'Add data' tab is highlighted in blue. The main canvas displays a report titled 'Real-time delivery of spatial-temporal information for farmers' with a sub-section 'Daily average data'. It includes three dropdowns: 'Select date range' (Jan 1, 2022 - May 24, 2022), 'Select farm' (farm), and 'Select paddock' (paddock). Below these are two charts: 'Time Series Chart - Daily average NDVI' and 'Time Series Chart - Daily average GNDVI, SWIR1, SWIR2'. To the right is a 'Data' panel for 'SatelliteDataDB' containing a list of available fields: b, cig, cire, date, evl, farm, g, gridv1, grvi, lat_long, lsvi, mndwi, ndvi, nir, paddock, QA60, r, re, re74, re78, re86, swr1, swr2, unmasked, and Record Count. Buttons for 'ADD A FIELD' and 'ADD A PARAMETER' are at the bottom of the panel.

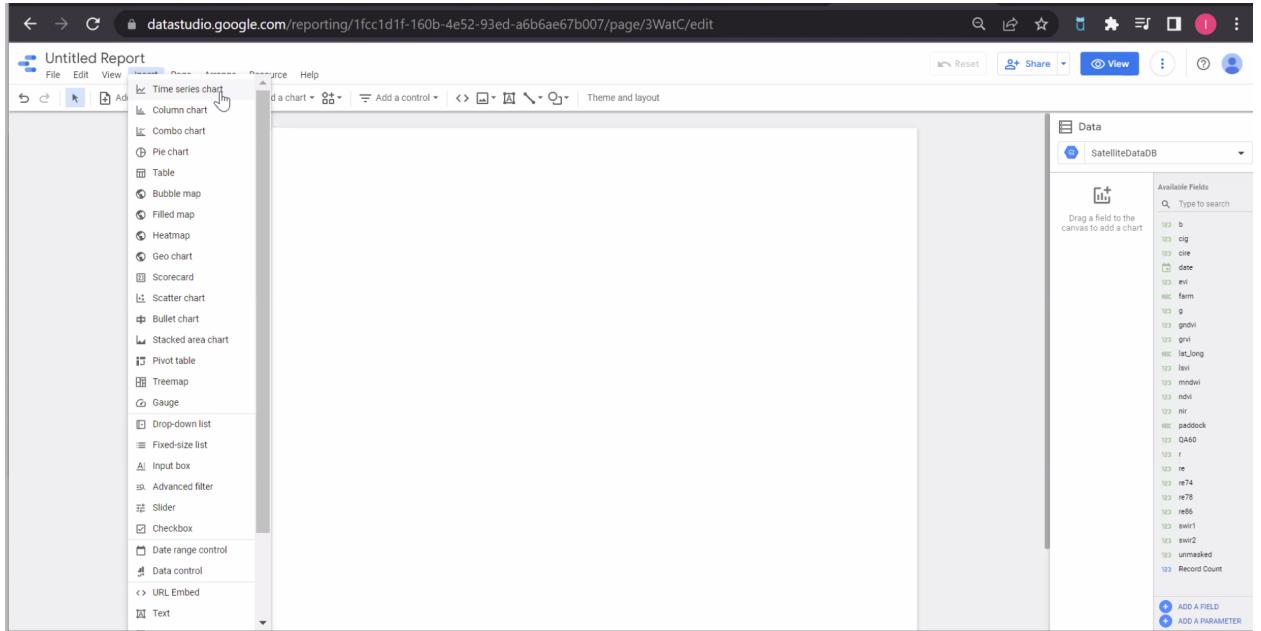
Select the data to add:

The screenshot shows the Google Data Studio interface for selecting data from BigQuery. The top navigation bar is identical to the previous screenshot. The main canvas shows a report titled 'Real-time delivery of spatial-temporal information for farmers'. Below it, a message encourages using the BigQuery BI Engine. The 'BigQuery' section is expanded, showing 'By Google' and a brief description of BigQuery as a managed data warehouse. Below this are 'LEARN MORE' and 'REPORT AN ISSUE' buttons. The 'RECENT PROJECTS' table lists 'MY PROJECTS' (Enter Project Id manually, aarsc_data, MonthlySatelliteDataSummary), 'SHARED PROJECTS' (aarsc-2022-cmpcprac, aarsc_import_data, SatelliteDataDB, MonthlySatelliteDataSummary), 'CUSTOM QUERY' (Earth Engine default project, My First Project), and 'PUBLIC DATASETS' (My Project, My Project). At the bottom are 'Cancel' and 'Add' buttons.

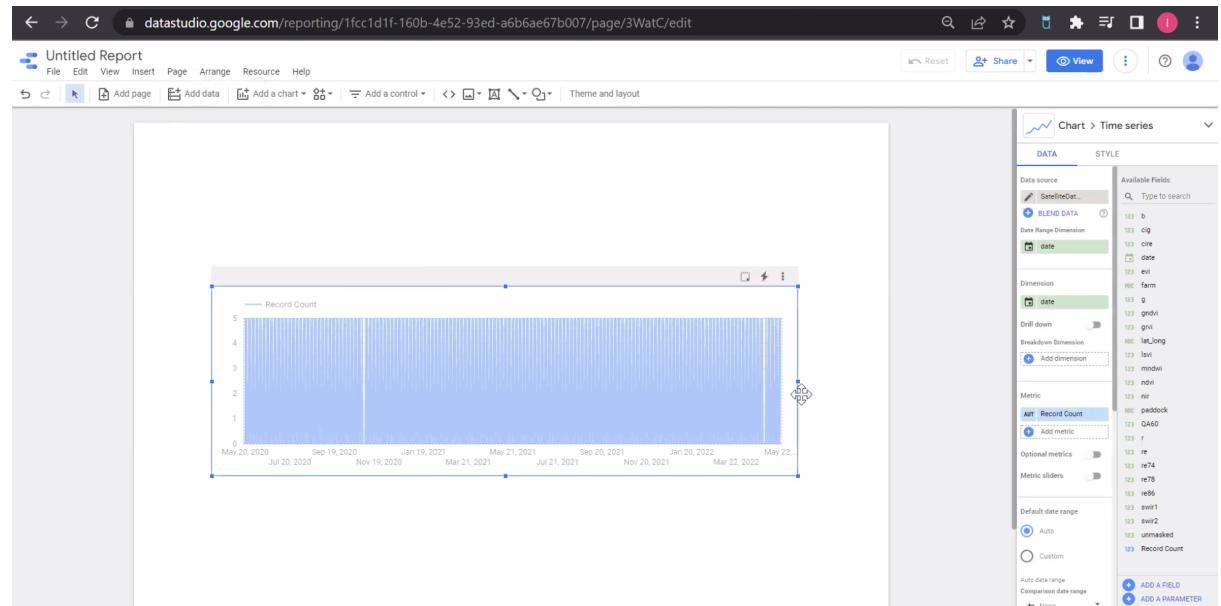
- Next, Select “add to report”:



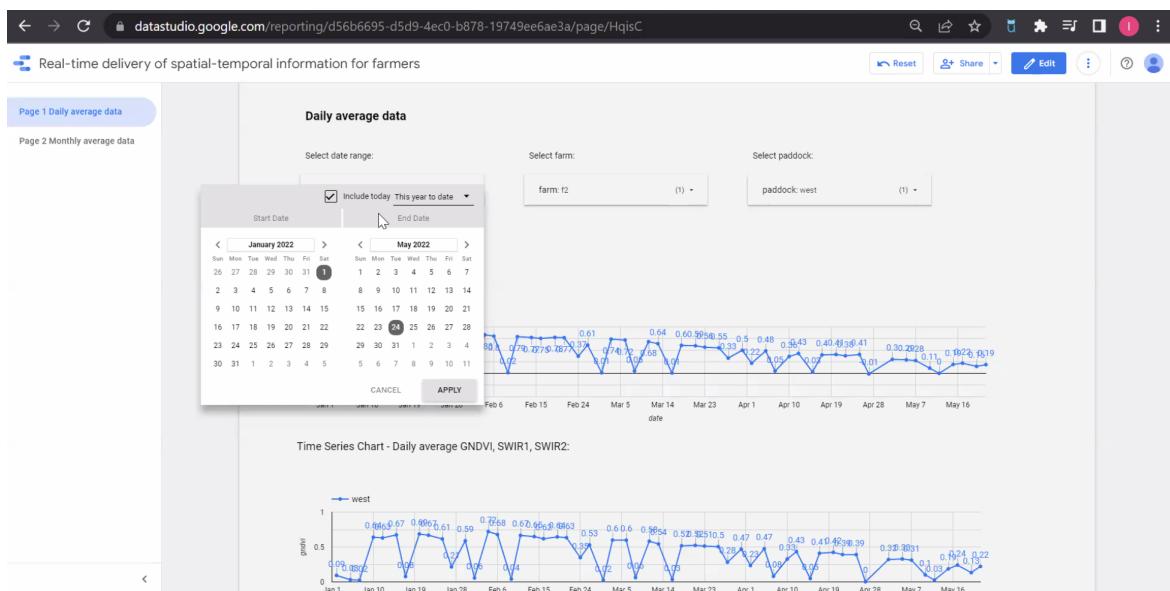
- The user has the option to pick different kinds of visual data representation formats (graphs, bubble map, etc) and can add the relevant fields of interest into the data representations within the report:



- The fields to add are located in the list to the right of the drop down screen of the selected data representation:

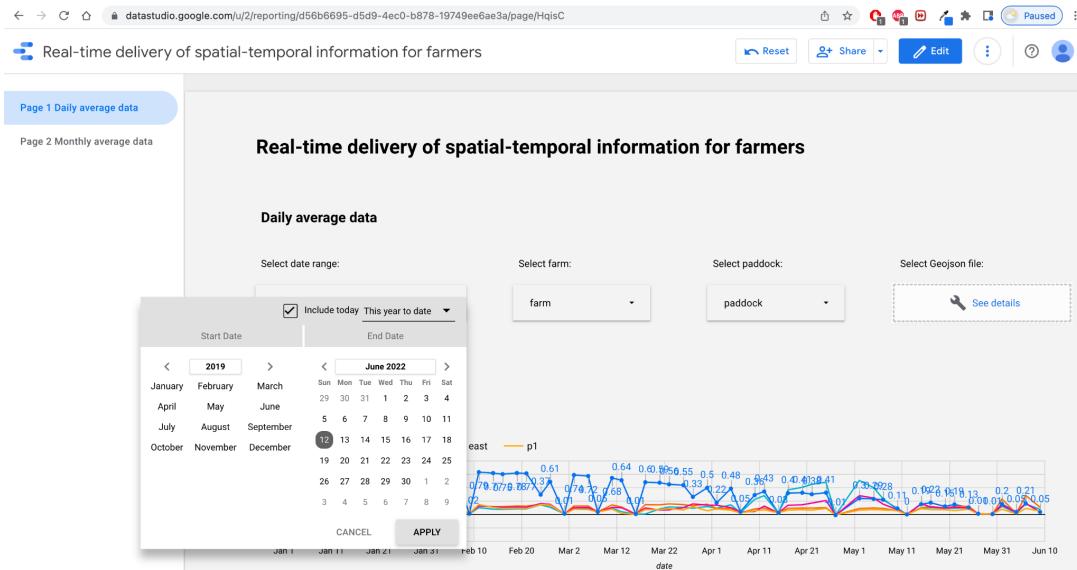


- Users can select the date range, farm or paddock from which they want to visualize data:



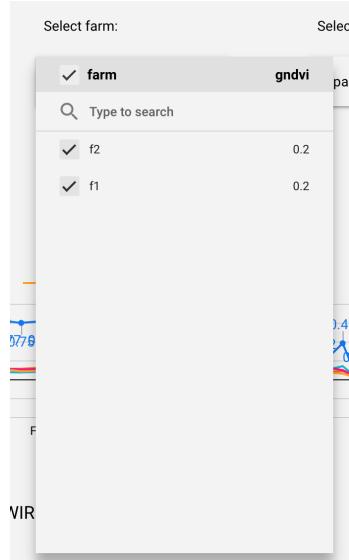
In the finished sample report the options to select are shown below:

Select Date range:



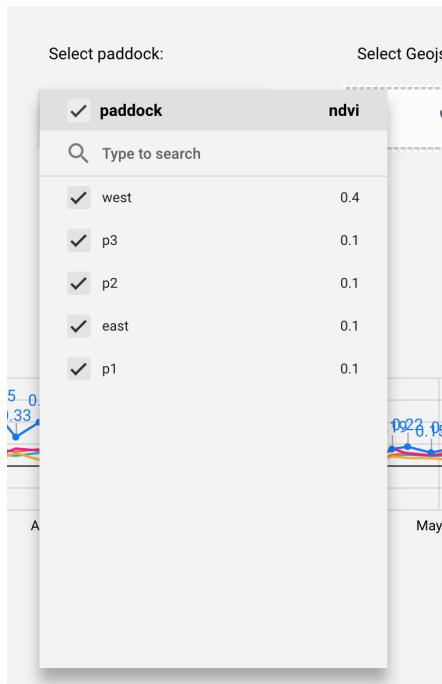
The screenshot shows a Google Data Studio report titled "Real-time delivery of spatial-temporal information for farmers". The report includes a line chart titled "Daily average data" showing metrics for a farm over time. A date range selector is open, showing a range from June 2022 to June 2022. The chart includes data for farm, paddock, and a GeoJSON file. The chart shows various metrics over time, with specific values labeled on the lines.

- Select farm:



The screenshot shows a "Select farm" dropdown menu. It lists three farms: f1, f2, and f3. The farm f1 is selected, indicated by a checkmark. The dropdown also includes a search bar and a "See details" button.

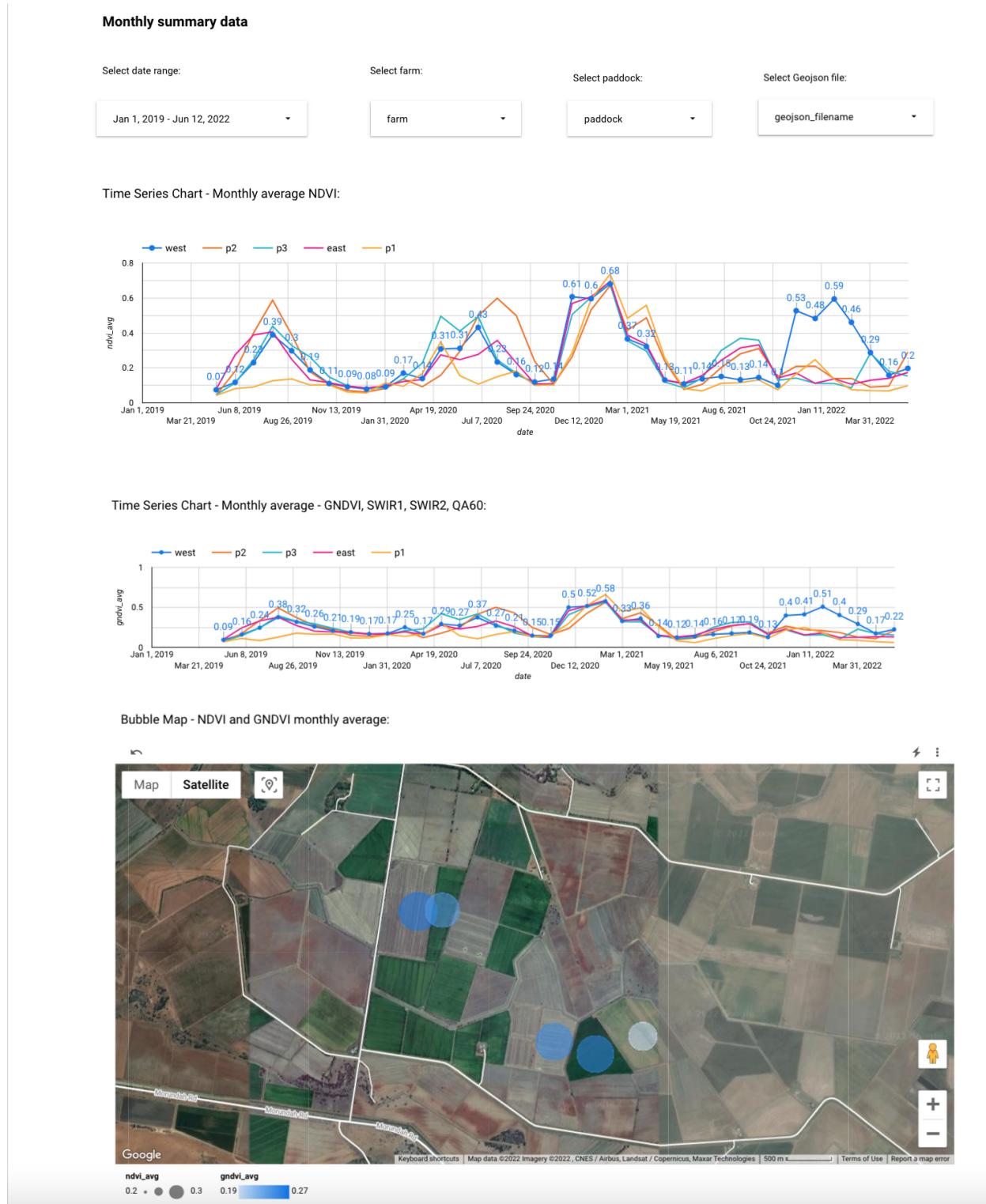
- Select Paddock:



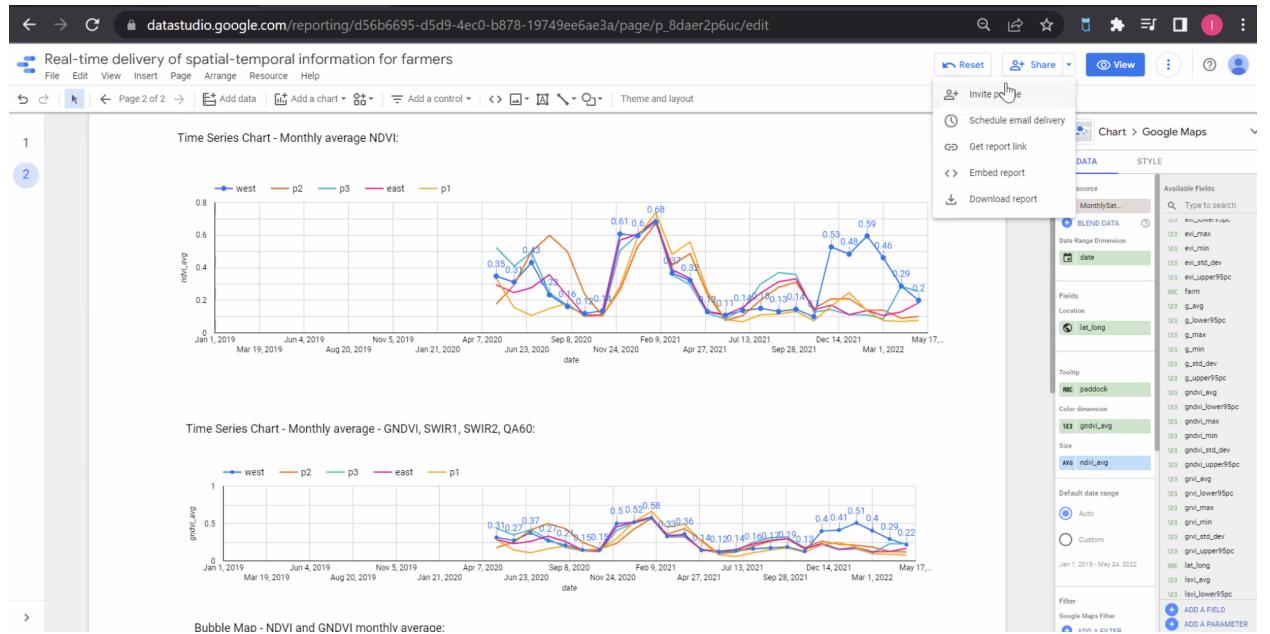
- The finished sample report is displayed below, the first page shows the “Daily average data” :



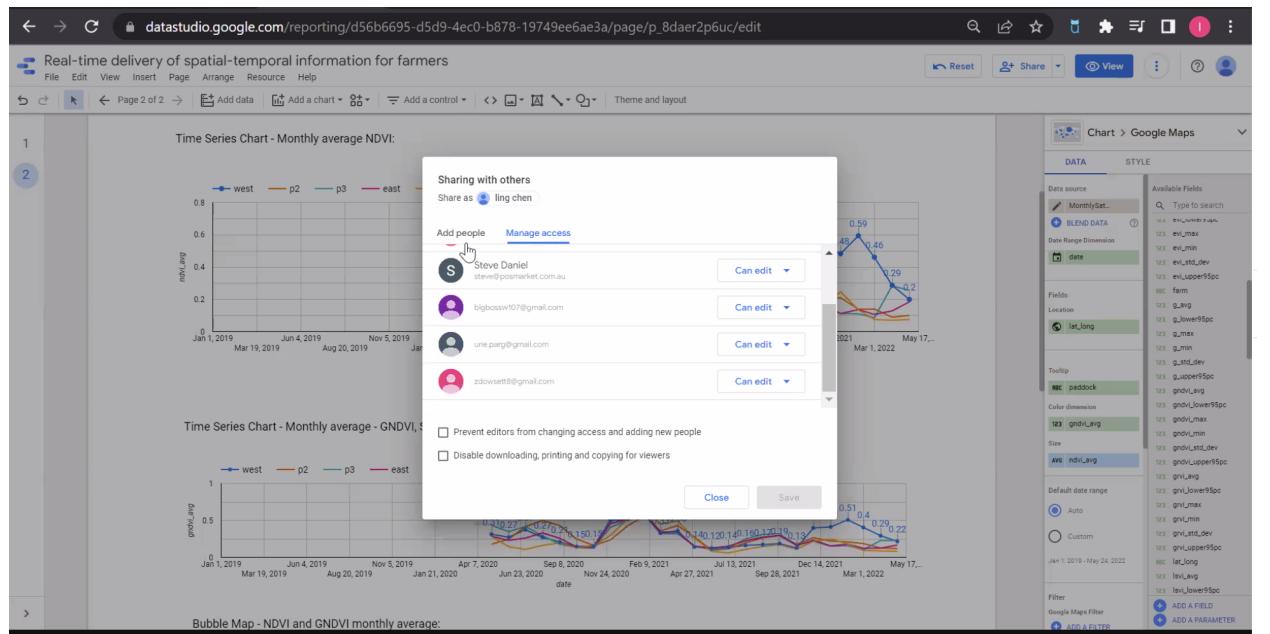
- while the second page shows the “Monthly summary data” :



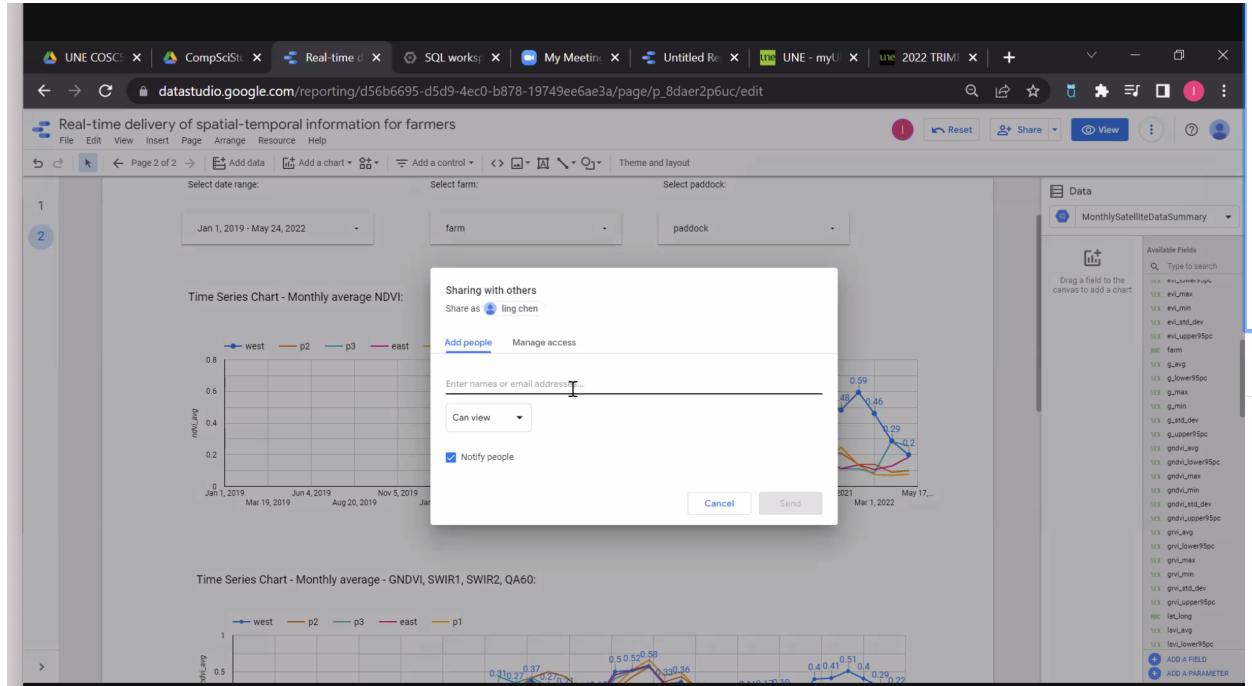
- To share the report, navigate to the top right of the page and click on the “Share+” tab button:



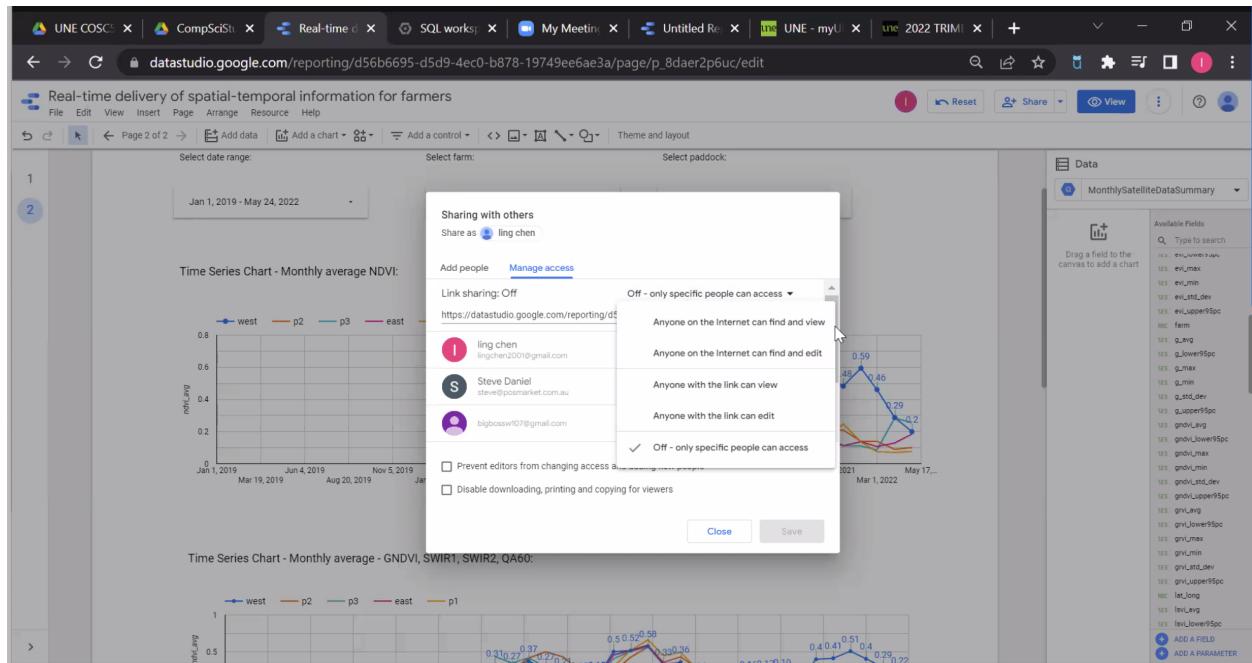
- The user can share the report by sending out an invitation for people to view the report:



- User has the option to add people to share with:



- The authorized user or owner of the report, can manage the access privileges that determine the permissions to view the report and the permissions to edit the report:



- The User is also able to generate a sharable link with the desired permissions to share publicly or with specific people, based on the intended scope of privacy:



- **Please note that:** all sharing, permissions, and management of access to the report can be accomplished via the “Share +” tab drop-down button located at the top right of the page.

This concludes the Installation and User Manual for CropWatch.
 To visit the open source github repository established by the author of this Installation and User Manual document, go to:
<https://github.com/Jase-The-Ace/CropWatch>

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